DISCOVERY

Studies on the incidence behavior and morphometry of Hilsa Fish, *Tenualosa ilisha* in relation to environmental attributes in the selected portion of the upper stretch of Hooghly estuary

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ABSTRACT

The Hooghly estuary, a distributary of Ganga-Bhagirathi River, located within the state of West Bengal, India, spanning across about 0.8 million ha is a positive estuary of mixohaline nature. The estuarine system lies between latitude 21 - 23^{0}N and longitude 88-89^{0}E. The Hooghly estuarine system is highly productive, since it receives substantial quantities of silt load and nutrients along with huge fresh water from Ganga. During tidal period significant amount of nutrients enter into the main channel and its tributaries making the entire system highly productive. There have been several studies on the pollution in the estuary has a thickly populated urban and highly industrialized centers of hinterland. These centers generated domestic and municipal sewage and industrial effluents, which find their way into the sea. The agricultural runoff also add to the pollution load. These are a number of small and large industries on the banks of the river Hooghly. The industries which may cause pollution from point sources include paper, textiles, chemicals, pharmaceuticals, plastics, shellac, food, leather, jute, pesticides, oil etc. The studies have revealed that domestic/municipal sewage contribute maximum (68.95%) pollution to the estuary. The impact of pollution on biota was seen at short distance below the on fall but overall there has been a poor biological quality of the estuary near industries indicating a general deterioration in the ecological conditions. Heavy metals are the normal constituents in marine and estuarine environment. Pollution of Hooghly estuary with trace metals has been on the rise. Sedentary organisms are adversely attacked by the trace metal pollution. Dictated by market value and popular preference, *Tenualosa ilisha* (Hilsa fish) ranks as the prime fish and commercially the most important fishery of the estuary. The monsoon (July - October) is earmarked as the main season for hilsa fishery, as the fish from the in shore areas of the sea ascends upstream mainly for spawning seeking fresh water stretches of the estuary. The low yield of hilsa in present day situation has arrived a question to find out the factors. In this regard factors like indiscriminate killing of juveniles, establishment of Farakha Barrage, decreasing depth of estuary, pollution state etc have been mentioned by different workers. Serampore - Uttarpara belt is famous for hilsa landing but no report from this area is available. Hence the work has under taken. From Bally to Serampore, five

stations (Bally, Uttarpara, Konnagar, Serampore and Ariadaha) have been selected. Physico-chemical natures of water and soil have been observed in each month round the year (2010). At the same time hilsa catch in different stations has also been recorded. Morphometric analysis of these fishes has also been worked out. From the observed data on hilsa fish catch it appears that in monsoon period (July to September) maximum hilsa fishes were caught during August and the majority of the fishes were 500 - 800 kg in weight. The range of average length and breadth were 24.62 to 27.36 cm (standard length 27.53 to 30.64 cm) and 7.16 to 9.06 cm (standard breadth 8.75 to 12.68 cm) respectively. These denote reduction of weight and size (Length and Breadth) of hilsa fishes in the estuary. Further, it has been seen that during 2005 the annual catch was observed as 90.25 kg/boat/station and within five years (2005-2010) the catch amount has been reduced to 41.50%. During the present study no adult fishes of 1.5 kg in weight were seen but during 2005 hilsa fishes bearing the same weight were observed in the estuary. During winter incidence (January to March) juvenile hilsa catch is also observed in low quantity. These indicate that hilsa fishes find inconvenience in migration to the estuary. The observed on the Physico-chemical parameters of water and soil reveals that dissolved oxygen content of water appears as 5.88 mgl^{-1} is not favorable for the growth of hilsa fish. Other parameters are not unfavorable for aquatic animals. Among the soil parameters available phosphorus (average 3.92mg/100gm), organic carbon (average 0.81 %) and heavy metals like zinc (average 55.28mg/100gm) and lead (average 28.00 mg/100gm) are marked relatively high. The total hydro-pedagogical conditions denote the pollution state of the water body in the estuary and adverse for growth and reproduction of hilsa fishes. Heavy metal pollution is detrimental to fish reproduction. Probably the pollution state leads to the uncongenial condition for the migration and reproduction of hilsa fishes. Perhaps for these reasons hilsa fishes move in another route leaving the pathway of Hooghly estuary. Present findings strongly demand the execution of immediate monitoring and control measures to protect the estuary enabling the steady migration of hilsa fishes as happened in ten or twenty years back.

Keywords: Hilsa shad; Monsoon; Morphometric analysis

1. INTRODUCTION

Hilsa shad (*Tenualosa ilisha*) is one of the most common and important anadromaous fish in West Bengal. It is also a very important commercial fish and one of the most popular fishes in Bengali cuisine. The Hilsa catch in Hooghly estuary is characterized by, wide fluctuations alluding normal scope of prediction. The annual catch of the species from the Hooghly estuary varied from 6448.2 to 15799t during 1998 – 2003 with an average catch of 10.382.9t showing 65.3% annual growth of catch compared to the average catch of 6279.6t of previous 05 years (from 1993 - 1998) (Nath et al., 2004). The annual contribution of the species to the total yield was found to be in the range of 10.2 to 21.9% (average being 15.7%)' However, hilsa catch from the estuary was the highest during 2000 - 2001 (15799t). It is surprising to note that the annual catch of the species plunged down to 6448.2 during 2002 - 2003, due to poor catch of hilsa during monsoon. Though monsoon (July to September) is the prime period of hilsa catch, another catch is also observed from January to March when the fish migrates up along the river course for breeding in fresh water' The large sized fishes corresponding to 03 - 05 years age group in the length range 20 to 55 cm were seen to dominate the catches of hilsa Contrastingly enough, the mean length of hilsa, which was braved to be 356 mm during period 1990 - 1994 to 1993 - 1994 (Mitra et al., 1994) had marked dipped to 325 mm during 2003 - 2004 (Nath et al. 2004). This not only represents an alarming situation, but also signals deteriorating recruitment of species in forcible future. In upper stretch of Hooghly estuary hilsa catch was a vigor source of income of a large number of fishermen families residing nearly the estuary belt rendering single trade hilsa catch programme. In this regard they invest fund (in purchasing boat and various nets) and time bound labour but not getting proper return in present situation. A few years back hilsa catch was a three months (July, August, and September) programme and that enabled them to maintain family expenses of about six months. The former condition has totally been changed and at present time three months efforts does not provide them with one month's expenses as the incidence of hilsa fish has drastically declined. Hooghly estuary is the ideal spot of hilsa catch. The total catch of hilsa fish has been reduced and the trend has been started since 2004 (Nath et al., 2004). For the reduction of hilsa catch, several factors including indiscriminate killing of juveniles (Konlauser, 1997; Amin et al., 2000), use of small meshed nets (Dutta et al., 2012), establishment of Farrakka Barrage (Haroon 1996) etc. have been put forwarded. Again the water and soil conditions of the estuary have been reported as uncongenial condition for aquatic lives (Nath et al., 2004, Banerjee and Banerjee, 2007). These must have effect in the ill migration of Hilsa shad in the estuary.

Water parameters of estuary were studied in various angles of various research workers. Water quality analysis was made by a lot of ecologists (Zindge and Desai, 1980; Mesre and Vinex, 1993, De, 1995; 1996; Gupta et al., 2001, Bhaumik et al., 2003; Borja et al., 2004). Variation in salinity of Water was referred by Sinha et al., (1995) and Ingile and Paruleker, (1998). Oxygen content of water was traced by Schuchardt et al., (1993); VanDamme et al., (1995), Linke Gamenick, (2000), Gurumayum et al., (2001) and Mishra, (2003). Variation of nitrate and phosphate content of water was observed in the findings of Ghosh and Banerjee, (1992); Das, (2002); Saha

and Mondal (2003) and Maques Junior et al., (2006). Sediment features of the estuary have been discussed in various attributes viz., physical nature, inorganic and organic constituents of soil. Physical nature of soil has been observed by Ramchandra et al., (1984); Chapman et al., (1987); Fernando and Fernando, (1988); Ajao and Fagade, (1990); Alonge, (1990); Edgar and Shaw, (1993); Prabhu et al., (1993); Rao and Sarma, (1999); and Lu and Wui (2000). Analysis of inorganic constituents of soil was made by a number of workers like Biswas, (1985), Me Luskey et al., (1993); Sanzgiry et al., (1998). Again, variation of organic contents of the soil was reported by several authors (Kristensen and Andrson, 1987; Pusceddu et al., 1996; Victor and Onomivbori, 1996; Jorenz, 1999; Forbes et al., 2000; Nath and Srivastava 2001; De Falo et al., 2004). A number of workers (Sunder and Subia, 1986; Pahwa, 1979; Singha and Srivastava, 1989; Kulshreshtha et al., 1989; Kumar, 1989 and 1998; Ansari and Parulaker, 1993; Acharjee et al., 2002; Khan, 2002, Samanta and Das, 2002; Sukumaran and Joshi, 2002; Hassan, 2003; Arasani et al., 2004) observed ecological features of the aquatic medium and its impact on macro benthic fauna of estuarine habitat. The Hooghly estuary, a distributary of Ganga-Bhagirathi river located within the state of West Bengal is carrying a heavy load of industrial, domestic and municipal effluents (Welcomme, 2006). The estuary has thickly populated urban and highly industrial centers of hinterland and their discharge of both organic and inorganic constituents to its water stretch has become a common phenomenon. The water course is also subjected to different anthropogenic activities leading to deterioration of water quality, thus threading to fish and fisheries of the aquatic ecosystem. Organic load is due to the municipal out fall of sewage where as inorganic load is mainly due to direct disposal of untreated byproducts of various small and large industries including paper, textile, pharmaceuticals, plastic, jute, food, leather etc (Nath and Srivastava, 2001). Again the upper and middle stretch of river is well documented with metal pollution (Singh et al., 1993 and 1997; Varma, 1995; Munshi et al., 2000). The existence of heavy metal in reverine system is detrimental to fish health (Nath et al., 2004). Besides, the observation on various attributes of Hilsa fishes including regular catch (Mitra et al., 2004), population structure (Rahman, 1997; Rahman et al., 2000; Halder et al., 2005; Banerjee et al., 2010), biometric analysis (Dey and Dutta, 1990; Rahman et al., 1997 and 1999), growth and mortality (Miah et al., 1997; Ahmed et al., 2008; Dutta et al., 2012), stock assessment (NurulAmin et al., 2002; Roonian and Jamily, 2011) etc have been reported by a number of workers. Virtually the studies on Hilsa shad is being extensively studied in Bangladesh and in West Bengal the study on the same issue is being carried out with a little extent. The population structure of *Tenualosa ilisha* in accordance with the present ecological status of upper stretch of Hooghly estuary has not yet been observed so far and hence the work has been undertaken.

2. MATERIALS AND METHODS

Limnological analysis

Water samples were collected from four studied stations. Collections were made first week of each month at 10-11 AM continuously during 2010 from January to December. The sampling sites were located at Bally (Station I), Uttarpara (station II), Konnagar (Station III), Serampore (station IV) and Ariadaha (Station V). In each station randomly selected four sub-samples were collected and mixed together to form a complete sample representing each sampling site. These samples were carried to the laboratory for chemical analysis.

Pedological analysis

The soil samples were collected from four studied stations. Collections were made first week of each month at 10-11 AM continuously during 2010 from January to December. The sampling sites were located at Bally (Station I), Uttarpara (Station II), Konnagar (Station III), Serampore (Station IV) and Ariadaha (Station V). In each station randomly selected four sub-samples were collected and mixed thoroughly together to form a complete sample representing each sampling site. The soil samples were made dried and powdered to use in chemical analysis. The collected wet samples were dried at room temperature. Then the samples were grinded and sieved. Finally, sediment dusts were analyzed following standard methods (Jackson, 1973).

Biotic sample analysis

For the study of the incidence of hilsa fish, the data of landed fishes from boat crew engaged in hilsa fishing at the referred stations had been taken in to account. The number of fishes per boat was counted. The length and weight of the captured fishes were taken properly. A few fishes as samples were preserved in formalin solutions. To know the socio-economic conditions of the fishermen personal interview was taken at the related night working sites of the fishermen of the studied stations.

2.1. Water Parameters

2.1.1. Measurement of Water temperature

It is determined by centigrade thermometer graduated at 0.1° C. interval (according to APHA., 1998).

2.1.2. Measurement of Water pH

The water samples were collected from studied stations and the pH was measured at the spot by pH papers. The water samples were taken to the laboratory and the pH was measured once again with pH meter. The average values of the two readings were taken as the final reading. Before analysis, the pH meter was calibrated with specific buffers.

2.1.3. Dissolved Oxygen (DO)

Dissolved Oxygen is estimated according to modified Winkler's method (1988).This is the most important chemical parameter to assess the water quality.

Requisites

a) Glasswares : 100 ml conical flasks, pipette, burette, measuring cylinder, volumetric flasks etc.

b) Reagents :

  i.   Manganous Sulphate ($MnSO_4$)

  ii. Alkaline Iodide (KI)

  iii. Conc. Sulphuric acid (H_2SO_4)

  iv. Sodium Thiosulphate ($Na_2 S_2O_3$)

  v.   Starch indicator

Procedure

After collection of water sample 1 ml $MnSO_4$ and 1 ml KI are added to it .Brown color flocculent precipitation settled in the bottom. Then 1 ml of Conc. Sulphuric acid is added to dissolve the precipitate. Next 50 ml of solution is taken in a conical flask and titrate with Sodium Thiosulphate till the color of the solution turns fade. Next 0.5 ml Starch indicator was added to form blue color and continue titration. At the end point the blue color was suddenly changed to colorless.

Calculation

$$\text{Dissolved Oxygen (mg / l)} = \frac{V_1 \times N \times E \times 1000 \times 0.698}{\dfrac{V_4 (V_2 - V_3)}{V_2}}$$

V_1 = Volume of titrant i.e., Sodium Thiosulphate (ml)

V_2 = Volume of water sample after placing the Stopper (ml)

V_3 = Volume of alkaline iodide and $MnSO_4$ added (ml) [Here 1 ml. KI + 1 ml. $MnSO_4$ was added]

V_4 =   Water volume taken for titration

E   = Equivalent weight of oxygen = 8

N   = Normality of $Na_2S_2O_3$ = 0.025

1000 = Conversion factor of ml. to litre

0.698 = Conversion factor of ml. to mg

2.1.4. Free Carbon di oxide (CO_2)

Free Carbondioxide is determined with the help of phenolphthalein indicator . Pink colour of the solution after mixing of indicator indicates absence of free CO_2, otherwise unchanged colour indicates presence of free CO_2 in water.

Requisites

  a) Glasswares : 100 ml conical flasks, pipette, burette, measuring cylinder,   volumetric flasks etc.

  b) Reagents :

     N / 44   NaOH Solution (Sodium Hydroxide); Phenolphthalein indicator

Procedure

Collected water sample was taken in a conical flask and 5-6 drops of phenolphthalein indicator was added and colour remains unchanged. Then titration was made with the solution of N / 44 NaOH until the colourless solution turns to slight pinkish colour.

Calculation

Free Carbondioxide (mg / l) $=$ $\dfrac{\text{ml. of NaOH X (N) of NaOH X 1000 X 44}}{\text{ml. of water sample taken for titration}}$

(N) of NaOH $=$ $\dfrac{1}{44}$

2.1.5. Chloride content (Salinity)

Silver Nitrate ($AgNO_3$) reacts with chlorine to form very slightly soluble white precipitate of silver chloride (Agcl). Free Ag^+ reacts with chromate to form silver chromate of reddish brown colour. Since, the proportion of radical remains virtually constant, total salinity may be computed by determining the chloride content of water sample.

Reagents

A. Silver nitrate, ($AgNO_3$)
B. Potassium chromate, 5% (K_2CrO_4)

Procedure

50 ml of sample was taken in an Conical flask and 2 ml of K_2CrO_4 was added . The contents were titrated against 0.02 (N) $AgNO_3$ until a persistent red tinge appeared.

Calculation

Chloride (mg / l) $=$ $\dfrac{\text{Volume of } AgNO_3 \text{ X Normality of } AgNO_3 \text{ X 1000 X Equivalent weight of } Cl^-}{\text{Volume of water sample}}$

Normality of $AgNO_3$ = 0.02(N)
Equivalent weight of Chlorine = 35.5

2.1.6. Total Nitrate content

To determine the amount of Nitrate in water, first it is distilled with alkali to release ammonia which is absorbed in an acid.

Requisites

a) Kjeldahl distillation set
b) Glass wares : Volumetric flasks, pipette etc
c) Reagents:
   i. 40% NaOH Solution
   ii. Davarda's alloy
   iii. Bromo Cresol green and Methyl red indicator
   iv. 4 % H_3BO_3 Solution
   v. Standard (0.02 N) H_2SO_4

Procedure

250 ml filtered water sample is taken in Kjeldahl flask and fit the flask with distillation set along with condenser. 20 ml of 4 % H_3BO_3 solution was taken in a conical flask and is placed beneath the condenser tip. Next, 0.5 gm Davarda's alloy was added to the water samples and mouth of Kjeldahl flask was closed to continue distillation upto dryness of water sample. Then distillate was accumulated in a receiving flask containing H_3BO_3 .Then distillate was titrated with 0.02 N H_2SO_4 till a pinkish colour was appeared.

Calculation

Nitrate in water $=$ $\dfrac{A \ x \ 280}{V}$

Where, A= ml of 0.02 N H_2SO_4 required for titration
       B= Volume (ml) of water sample used.

2.1.7. Phosphate Content

Water Phosphate is estimated calorimetrically after development of phosphomolybdic blue colour.

Requisites

a) Colorimeter
b) Glass wares - Volumetric flasks, pipette etc
c) Reagents
   i. Standard P solution
   ii. Ammonium molybdate-Potassium antimony tartarate solution
   iii. Ascorbic acid – molybdate solution

Procedure

Initially a standard curve with different concentration of Phosphate was prepared. Then 5-10 ml of water sample was taken in 25 ml volumetric flasks, depending on expected concentration of   Phosphate in water. A blank flask was also taken. Then adequate amount of distilled water and 5 ml of ascorbic acid-molybdate mixture were added. Next the volume was adjusted upto 25 ml.Then the OD (Optical Density) was determined. OD value of unknown water sample was put on the standard curve to get the concentration of Phosphate in the volumetric flasks.

Calculation

Concentration (ppm) of Phosphate in water $\dfrac{\text{'X'} \times 25}{\text{'V'}}$

X = The concentration of Phosphate in 25 ml. volumetric flask.
V = The initial volume of water sample taken in the flask.
Then the results are converted to mg / l .

2.2. Soil Parameters

2.2.1. pH

Soil pH has been determined by potentiometric method. Portable battery operated pH meter was also used to determine soil pH.

2.2.2. Available Nitrogen (Average)

Nitrate ions become available in water phase determined by extracting luis ions from acidified potassium chloride solution (KCl) as stated by Jachson., 1973)

Reagents

i. 10% Chloride (pH 2.5).
ii. 2-4 Dinitrophenol indicator.
iii. 0.02 N Sulphuric Acid (H_2SO_4)
iv. Boric acid(H_3BO_3)
v. 40% Sodium hydroxide(NaOH)
vi. Darvada's alloy

Procedure

100 gm. of soil was taken in a conical flask and 200ml NaCl (pH 2.5) was added. Then the contents were shaken thoroughly for half an hour. Next the suspension was filtered and washed with additional 50 ml of NaCl. The filtrate was taken in a Kjeldahl flask, 1 ml. of liquid paraffin was added. A few glass beads and 0.5 gm. of Davarda's alloy were also added. The distillation was continued to dryness and the H_3BO_3 was titrated with standard 0.02 N H_2SO_4 until a pink colour develop.

Calculation

If the volume of 0.02 N H_2SO_4 required for titration is 'X' ml , then the amount of Nitrate (NO_3) in soil = 'X 'x 0.28 mg /100gm soil.

2.2.3. Available Phosphorus (Average)

Determination of soil Phosphate involves shaking the soil sample with 0.002 N H_2SO_4, buffered at pH 3.0, and determination of P concentration in the extract.

Requisites

(i)   Colorimeter

(ii)   Mechanical shaker.

(iii)   Glass wares: (i) Bottles, (ii) Conical Flasks, (iii) Funnels, (iv) Volumetric Flasks, (v) Pipettes, (vi) Burrette etc.

(iv)   Reagents:

    a)   0.002N H_2SO_4,

    b)   Ammonium molybdate ($(NH_4)_6\ Mo_7O_{24}$, $4H_2O$)

    c)   Ascorbic acid- molybdate solution

    d)   Standard (2ppm) P solution

Procedure

1 gm. soil sample was taken in a bottle and 0.002(N) H_2SO_4 was added. Then suspension was shaken for half an hour in mechanical shaker and the suspension was filtered to estimate the concentration of Phosphate in Colorimeter with the help of standard curve with different concentration of Phosphate. Optical Density (OD) value of unknown sample was put on the standard curve to get the concentration of Phosphate in the volumetric flasks.

Calculation

If the colorimetric reading is 'X 'ppm of P in the solution of volumetric flask, the amount of available P in the soil will be 'X' x 500 ppm.

2.2.4. Organic Carbon

It denotes presence of nutrient elements in soil. It also maintain productivity of water body

Requisites

 i.   Glasswares : 500 ml conical flasks, pipette, burette, measuring cylinder, volumetric flasks

ii.   Reagents :

    a)   Potassium dichromate1 N($K_2Cr_2O_7$).

    b)   Ferrous ammonium sulphate 1(N) $Fe(NH_4)_2(SO_4)_2$

    c)   Diphenyl amine indicator.

    d)   Concentrate Sulphuric Acid (H_2SO_4).

    e)   85 % Orthophosphoric Acid (H_3PO_4).

Procedure

Initially digestion was made with 1(N) $K_2Cr_2O_7$ and concentrated H_2SO_4. Then H_3PO_4 and Diphenyl amine indicator were added to the solution. Finally the solution was titrated by Mohr's solution [$Fe(NH_4)_2(SO_4)_2$]. The colour was changed at the end-point from blue to bottle green.

Calculation

Organic Carbon (%) = (B – A) X 0.3

2.2.5. Sediment texture

Textural composition of soil can be estimated by means of mechanical analysis. This consists essentially of two distinct operations viz, dispersion of soil to ultimate grain sizes (sand, silt and clay) and grading the dispersed grains according to their groups.

2.2.6. Heavy metal sample analysis

Both physical and biotic samples made dry ashed for metal analysis. In dry-ashing method known quantity of sample was ashed in Muffle Furnace (550-600° C) and then dissolved in tri-acid mixture. During this process the samples were taken in Borosil hard glass

test tubes. For each gram of sample, 5 ml of conc. Nitric acid was added and then digested overnight at room temperature. The mixture was placed in a hot plate at temperature $85 \pm 5 °C$ and 5 ml (3 : 2 conc sulphuric acid : perchloric acid) was then added to it. The digestion was carried out until the mixture was turned into a pale yellow transparent solution. It was cooled and filtered through an acid soaked filter paper and was adjusted to the required volume (20 ml) with distilled water. Metals were detected in AAS (Atomic Absorption Spectrophotometer).

2.3. Incidence of Hilsa Shad

The incidence of hilsa fish was counted throughout year whenever catch samples were available. In observation five boat samples per station were taken into account. Then average value of the result has been worked out. The length and weight of the fish sample of all stations have properly be done.

2.4. Site selection for Sampling
2.4.1. Station I : Bally

The site is linked with the municipal town Bally in the district of Howrah where the mouth of Bally khal is situated. The said khal (canal) was once excavated to send water to the interior villages surrounding the region Bally for cultivation. In course of time a large number of industrial set-up have developed on either side of the canal including Bally Jute mill,Mother Diary, Colour production centre, Plastic factory etc. The water course of the canal carries effluent load discharged from the factories which ultimately mix with the water of the river Ganga. Geographically the latitude and the longitude are   22∘ 03'(N) and 88∘ 02'(E) respectively.

2.4.2. Station II : Uttarpara

The site is linked with municipal town Uttarpara in the district of Hooghly .The station is 3 kms away from station I towards south. It is also on the western bank of the river. Town Uttarpara though small in volume but large with its population load.

Table 1

Physico-Chemical parameters of Water in the studied stations, 2010 (Station I - Bally)

Month Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
pH	7.1	7.2	7.4	8.1	8.2	8.2	7.9	7.6	7.5	7.2	7.3	7.8	**7.62**
Temp (°C)	22.8	23.6	25.2	26.1	27.1	26.4	22.6	22.7	23.3	23.3	22.6	21.9	**23.97**
DO (mg/l)	5.3	5.3	6.2	6.2	5.3	5.2	5.8	5.3	5.6	5.8	6.2	6.2	**5.70**
CO_2 (mg/l)	5.1	5.3	6.2	6.1	6.1	4.4	5.2	5.1	4.8	4.8	5.6	5.4	**5.34**
NO_3 (mg/l)	0.17	0.18	0.18	0.22	0.17	0.17	0.16	0.17	0.16	0.17	0.16	16	**1.49**
PO_4(mg/l)	0.08	0.08	0.07	0.06	0.07	0.08	0.11	0.11	0.12	0.12	0.11	0.09	**0.09**
Salinity (mg/l)	16.1	14.2	15.1	15.1	14.5	15.1	13.8	13.7	12.9	13.3	14.5	14.8	**14.43**

Table 1

Physico-Chemical parameters of Water in the studied stations, 2010 (Station II - Uttarpara)

Month Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
pH	7.2	7.1	7.3	7.6	8.1	8.2	8.1	7.9	7.8	8.1	8.1	7.8	**7.77**
Temp (°C)	21.4	24.3	27.1	28.1	27.5	26.3	24.7	24.5	24.3	23.3	22.8	21.6	**24.66**
DO (mg/l)	5.2	6.1	7.1	7.2	7.1	5.9	7.1	5.8	5.7	5.8	5.8	6.4	**6.27**
CO_2 (mg/l)	3.8	4.1	5.2	5.3	6.1	6.1	5.6	4.8	5.1	5.1	4.8	4.7	**5.06**
NO_3 (mg/l)	0.13	0.16	0.17	0.17	0.15	0.17	0.18	0.14	0.17	0.17	0.16	0.14	**0.16**
PO_4(mg/l)	0.12	0.13	0.09	0.11	0.11	0.13	0.14	0.14	0.13	0.14	0.11	0.11	**0.12**
Salinity (mg/l)	15.1	16.1	15.3	15.2	16.2	15.2	14.1	12.6	11.4	12.1	13.5	14.8	**14.30**

Table 1

Physico-Chemical parameters of Water in the studied stations, 2010 (Station III - Konnagar)

Month Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
pH	7.8	7.8	8.1	8.3	8.1	8.2	8.2	8.3	7.9	8.4	8.3	7.4	**8.07**
Temp (°C)	22.2	23.4	25.3	26.1	26.2	25.4	23.9	23.1	24.1	23.6	22.8	21.5	**23.97**
DO (mg/l)	5.8	5.5	4.8	5.4	6.1	5.3	5.2	6.1	5.8	5.6	6.1	5.8	**5.63**
CO_2 (mg/l)	4.2	4.3	4.2	5.1	4.6	5.3	5.2	4.8	4.6	4.6	4.8	5.1	**4.73**
NO_3 (mg/l)	0.22	0.18	0.15	0.16	0.17	0.17	0.2	0.18	0.18	0.19	0.19	0.2	**0.18**
PO_4 (mg/l)	0.09	0.09	0.13	0.09	0.12	0.11	0.09	0.09	0.13	0.12	0.11	0.09	**0.11**
Salinity (mg/l)	11.3	9.4	11.1	10.2	9.4	10.1	11.2	10.6	13.1	12.6	12.6	9.8	**10.95**

Table 1

Physico-Chemical parameters of Water in the studied stations, 2010 (Station IV - Serampore)

Month Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
pH	7.2	7.3	7.4	8.2	8.1	7.6	7.4	7.6	7.4	8.1	7.1	7.6	**7.58**
Temp (°C)	22.2	24.1	25.1	26.2	26.1	25.3	24.1	24.2	25.1	23.8	22.8	21.6	**24.22**
DO (mg/l)	6.1	6.1	6.1	5.7	5.6	5.7	6.1	5.8	6.1	6.1	5.8	5.8	**5.92**
CO_2 (mg/l)	5.1	5.1	6.2	5.3	5.2	6.1	5.1	5.2	6.1	6.2	6.2	5.5	**5.61**
NO_3 (mg/l)	0.21	0.21	0.18	0.17	0.18	0.24	0.24	0.22	0.22	0.21	0.22	0.22	**0.21**
PO_4 (mg/l)	0.17	0.16	0.16	0.15	0.15	0.17	0.17	0.16	0.15	0.15	0.16	0.15	**0.16**
Salinity (mg/l)	16.1	15.2	14.4	14.4	15.1	14.6	13.7	12.8	12.8	12.6	13.5	14.2	**14.12**

Table 1

Physico-Chemical parameters of Water in the studied stations, 2010 (Station V - Ariadaha)

Month Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
pH	7.3	7.3	7.6	7.4	8.1	8.2	7.8	7.6	7.7	7.8	7.8	7.6	**7.68**
Temp (°C)	21.1	23.3	24.1	26.1	26.1	25.6	24.2	24.2	25.1	23.8	22.8	21.8	**24.02**
DO (mg/l)	5.2	5.2	5.3	6.1	6.1	6.2	6.2	6.1	6.3	6.3	5.3	6.1	**5.87**
CO_2 (mg/l)	4.4	4.4	4.5	5.1	5.1	5.2	6.1	6.1	5.3	5.3	6.4	6.3	**5.35**
NO_3 (mg/l)	0.21	0.21	0.18	0.22	0.22	18	0.18	0.2	0.21	0.21	0.20	0.21	**1.69**
PO_4 (mg/l)	0.16	0.15	0.13	0.13	0.13	0.14	0.15	0.16	0.16	0.16	0.15	0.14	**0.15**
Salinity (mg/l)	14.3	14.2	15.1	13.2	13.3	12.4	14.1	11.8	12.5	12.3	11.8	13.6	**13.22**

The sewage effluents of the said population load is getting discharge daily on the river water course. The sampling station has been selected near to the effluent disposal site on the river bed. Geographically the latitude and the longitude are 22° 66′(N) and 88° 34′(E) respectively.

2.4.3. Station III: Konnagar

The site is linked with municipal town Konnagar in the district of Hooghly and that remains at the western bank of the river Ganga. On the bank of the river Shaw-Wallace Wine Factory is situated. The station III has been selected near to the outfall of factory effluents over the river Ganga. Geographically the latitude and the longitude of the site are 22° 57′(N) and 88° 36′(E) respectively.

2.4.4. Station IV : Serampore

The station is situated on the western bank of the river Ganga. The town belongs to the district of Hooghly. The interference of effluent output from the factories and municipality are optimum here. Geographically the latitude and longitude are 22^0 9(N) and 88.46 (E).

Table 2

Physico Chemical Parameters of Soil in the studied stations, 2010 (Staion I – Bally)

Month Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
pH	8.5	9.1	8.7	8.7	8.8	9.1	8.6	8.7	9.1	9.1	8.8	8.6	**8.82**
Av. Nitrogen (mg/100 gm)	14.2	13.2	11.5	12.6	12.6	12.6	11.8	13.2	13.2	13.2	11.8	12.6	**12.71**
Av. Phosphorus (mg/100 gm)	4.7	4.1	3.8	3.6	3.3	3.4	3.6	3.3	3.2	3.3	3.6	3.4	**3.61**
Or. Carbon (%)	0.92	0.94	0.85	0.91	0.78	0.79	0.82	0.83	0.82	0.85	0.82	0.85	**0.85**
Sand (%)	20	25	20	25	22	25	20	21	22	22	24	23	**22.42**
Silt (%)	50	55	53	52	51	52	53	54	52	56	53	52	**52.75**
Clay(%)	30	20	27	23	27	23	27	25	26	25	27	28	**25.67**

Table 2

Physico Chemical Parameters of Soil in the studied stations, 2010 (Staion II – Uttarpara)

Month Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
pH	8.2	8.2	8.2	9.1	9.1	9.1	9.1	9.1	8.3	8.4	9.1	8.5	**8.70**
Av. Nitrogen (mg/100 gm)	14.1	13.3	13.3	14.1	14.1	14.1	15.1	15.2	15.2	15.1	15.2	14.1	**14.41**
Av. Phosphorus (mg/100 gm)	4.5	4.5	5.1	5.1	5.1	4.4	4.4	4.3	4.5	4.6	4.3	4.4	**4.60**
Or. Carbon (%)	0.76	0.77	0.76	0.78	0.81	0.81	0.81	0.81	0.84	0.84	0.82	0.78	**0.80**
Sand (%)	20	21	20	28	28	28	20	20	22	22	23	28	**23.33**
Silt (%)	45	45	44	46	45	44	46	45	43	45	46	45	**44.92**
Clay(%)	35	34	36	26	27	28	34	35	35	35	34	33	**32.67**

Table 2

Physico Chemical Parameters of Soil in the studied stations, 2010 (Staion III – Konnagar)

Month Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
pH	8.6	9.1	8.7	8.8	8.7	9.1	8.6	8.7	8.8	8.8	8.5	8.3	**8.73**
Av. Nitrogen (mg/100 gm)	14.1	13.3	11.5	12.5	12.6	12.5	11.6	13.2	13.2	13.2	11.5	14.3	**12.79**
Av. Phosphorus (mg/100 gm)	4.7	4.1	3.8	3.5	3.3	3.4	3.5	3.3	3.1	3.3	3.4	4.1	**3.63**
Or. Carbon (%)	0.93	0.91	0.85	0.88	0.79	0.79	0.74	0.73	0.75	0.75	0.81	0.81	**0.81**
Sand (%)	22	25	20	25	22	25	22	21	22	23	22	22	**22.58**
Silt (%)	50	55	52	53	51	52	53	54	52	53	53	51	**52.44**
Clay(%)	28	20	28	22	27	23	27	25	26	25	23	22	**24.67**

Table 2

Physico Chemical Parameters of Soil in the studied stations, 2010 (Staion IV – Serampore)

Month Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
pH	8.7	8.8	8.7	9.1	8.6	8.7	8.8	8.6	9.1	8.8	8.7	8.7	**8.78**

Av. Nitrogen (mg/100 gm)	12.5	11.6	13.2	13.2	14.1	13.3	13.3	14.1	14.1	14.1	13.6	13.3	**13.37**
Av. Phosphorus (mg/100 gm)	4.7	4.1	3.8	3.6	3.3	3.4	3.6	4.7	4.1	3.8	3.8	4.1	**3.92**
Or. Carbon (%)	0.76	0.77	0.76	0.78	0.81	0.81	0.81	0.81	0.78	0.74	0.81	0.78	**0.79**
Sand (%)	22	22	25	22	20	21	22	21	23	22	21	22	**21.92**
Silt (%)	53	51	52	53	54	52	50	55	52	53	54	54	**52.44**
Clay(%)	25	27	23	25	26	27	28	24	25	23	22	27	**25.17**

Table 2

Physico Chemical Parameters of Soil in the studied stations, 2010 (Staion V – Ariadaha)

Month / Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average
pH	9.1	9.1	9.1	9.1	8.3	8.6	9.1	8.6	8.7	8.6	8.7	8.8	**8.82**
Av. Nitrogen (mg/100 gm)	12.6	11.8	13.2	13.2	12.5	11.6	13.2	13.2	14.1	13.8	14.1	14.2	**13.13**
Av. Phosphorus (mg/100 gm)	3.3	3.4	3.6	4.7	4.1	4.7	4.1	3.8	3.6	3.8	3.5	3.7	**3.86**
Or. Carbon (%)	0.84	0.84	0.84	0.79	0.82	0.79	0.76	0.82	0.84	0.82	0.81	0.83	**0.82**
Sand (%)	22	25	20	21	23	22	25	22	21	22	24	24	**22.58**
Silt (%)	51	52	52	54	52	48	45	52	51	52	52	50	**50.92**
Clay(%)	27	23	28	25	25	30	30	26	28	26	28	28	**27.00**

Table 3

Average value of water parameters in the studied stations from January to December 2010

Parameters	Station I	Station II	Station III	Station IV	Station V	Average
pH	7.62	7.77	8.06	7.58	7.68	**7.742**
Temp (°C)	23.96	24.66	23.97	24.22	24.02	**24.17**
DO (mg/l)	5.70	6.27	5.63	5.92	5.87	**5.88**
CO_2 (mg/l)	5.34	5.06	4.73	5.61	5.35	**5.22**
NO_3 (mg/l)	1.49	0.16	0.18	0.21	1.69	**0.75**
PO_4 (mg/l)	0.09	0.12	0.11	0.16	0.15	**0.13**
Salinity (mg/l)	14.43	14.30	10.95	14.12	13.22	**13.40**

Table 4

Average value of Soil parameters in the studied stations from January to December

Parameters	Station I	Station II	Station III	Station IV	Station V	Average
pH	8.82	8.70	8.73	8.78	8.82	**8.77**
Av. Nitrogen (mg/100 gm)	12.71	14.41	12.79	13.37	13.13	**13.28**
Av. Phosphorus (mg/100 gm)	3.61	4.60	3.63	3.92	3.86	**3.92**
Or. Carbon (%)	0.85	0.80	0.81	0.79	0.82	**0.81**
Sand (%)	22.42	23.33	22.58	21.92	22.58	**22.57**
Silt (%)	52.75	44.92	52.44	52.44	50.92	**50.69**
Clay(%)	25.67	32.67	24.65	25.17	27.00	**27.03**

Table 5

Heavy Metal Contents in Water (mg/l) in Stations Bally, Uttarpara, Serampore and Ariadaha (Jan-Dec'2010)

Metal	Station I	Station II	Station III	Station IV	Station V	Average
Zn	0.01-0.04 (0.02)	0.04-0.6 (0.05)	0.04-0.07 (0.05)	0.03-0.08 (0.05)	0.04-0.08 (0.06)	**0.05**
Pb	0.38-0.62 (0.50)	0.40-0.52 (0.45)	0.18-0.55 (0.36)	0.21-0.44 (0.32)	0.15-0.46 (0.30)	**0.38**
Cd	0.03-0.08 (0.05)	0.38-0.48 (0.43)	0.18-0.44 (0.31)	0.28-0.46 (0.37)	0.28-0.50 (0.39)	**0.31**
Cu	Tr-0.08 (0.04)	Tr-0.10 (0.05)	Tr-0.08 (0.04)	0.02-0.08 (0.05)	0.03-0.07 (0.05)	**0.05**
Cr	0.01-0.07 (0.04)	0.07-0.09 (0.08)	0.05-0.09 (0.07)	0.06-0.10 (0.08)	0.03-0.07 (0.05)	**0.06**

Table 6

Heavy metal Content in Soil (mg/kg) in stations Bally, Uttarpara, Serampore and Ariadaha (Jan-Dec'2010)

Metal	Station I	Station II	Station III	Station IV	Station V	Average
Zn	40.81-62.24 (51.02)	35.80-71.60 (53.70)	28.48-86.90 (57.69)	34.55-77.10 (55.82)	50.55-65.86 (58.20)	**55.28**
Pb	11.00-16.90 (13.90)	33.00-42.60 (37.80)	28.62-32.84 (30.73)	30.51-34.61 (32.56)	25.62-32.43 (29.02)	**28**
Cd	2.41-2.82 (2.61)	3.80-4.20 (4.00)	4.11-5.22 (4.66)	1.80-2.22 (2.01)	1.62-2.43 (2.02)	**2.7**
Cu	12.00-16.22 (14.11)	16.30-18.63 (17.46)	32.84-34.43 (33.61)	18.51-20.32 (19.41)	27.21-28.82 (28.01)	**22.55**
Cr	23.42-32.83 (28.15)	20.26-30.42 (28.34)	18.04-36.06 (27.05)	15.32-24.16 (19.74)	22.16-32.62 (27.38)	**26.12**

2.4.5. Station V : Ariadah

It is linked with the town Ariadah near to the well known Kali temple of Dakshineswar. It is situated on the eastern bank of the river Ganga and nearly opposite toUttarpara, Station 2. The town belongs to the district of North 24 Parganas. The interference of effluent output from factories and municipalities are minimum here. Geographically the latitude and the longitude are 22° 82 '(N) and 88° 30'(E) respectively.

3. RESULTS

3.1. Physico-Chemical Characteristics of water

The referred water parameters have been observed in five studied stations and these have been displayed in Table 1 and Table 3 and in Figure 1.

3.1.1. pH

The water in Hooghly estuary and its different statures was slightly alkaline incretion (pH 7.74) which is considered as congenial for aquatic habitats. Bally and Ariadaha statures showed slightly lower pH than other stations.

3.1.2. Temperature

The minimum water temperature (21.1 - 22.8°c) was recorded during winter (December - February), while maximum temperature (25.3 - 28.1°c**)** was found during summer (May -June). Thermal stratification was not deflectable in the Hooghly estuarine system, presumably due to tidal effect. Average water temperature of the distributaries ranged between 24.13 - 25.12°c Konnagar station was marked for the minimum while the maximum was recorded at Bally. The water temperature in Hooghly estuary as well as in the distributaries is apparently conducive for growth of fish and other aquatic organisms (Nath et al., 2004).

3.1.3. Dissolved Oxygen

Maximum dissolved oxygen (mgl^{-1}) was recorded at Uttarpara (average 6.27 mgl-^{1}) followed by Serampore (5 - 92 mgl-^{1}) and Ariadaha (5 - 84 mgl-^{1}), Dissolved oxygen content in the Hooghly estuary and, its stations maintained the level in the range of 5.70 - 6.27 mgl-^{1} which is relatively low and that indicates the unfavourable situation for fishes and other aquatic organism's growth.
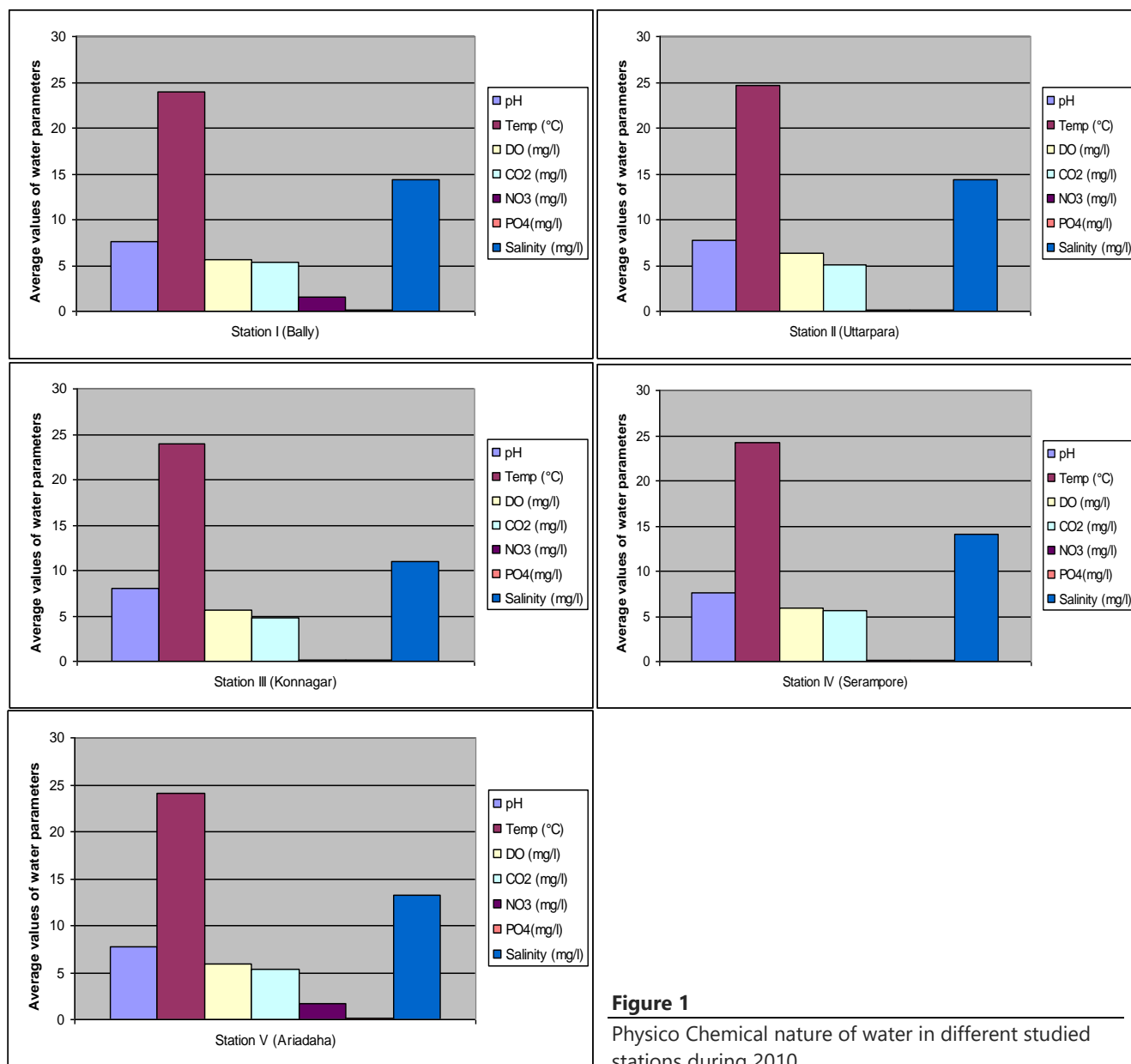
Figure 1

Physico Chemical nature of water in different studied stations during 2010

3.1.4. Free CO₂

Free CO_2 content ranged between 4.73 - 5.61 mgl^{-1} in different studied stations. In totality the average volume of CO_2 content was marked as 5.22 mgl^{-1}. Relatively more CO_2 was seen at station IV and the less amount of CO_2 was seen at station - III.

3.1.5. Salinity

Salinity was ranged from 10.95 to 14.43 mgl^{-1}. Maximum amount (14.43mgl^{-1}) of salinity was seen at station- II and the minimum amount (10.95 mgl^{-1}) was at station- II.

3.1.6. Nitrate

Nitrate content in Hooghly estuary ranged between 0.16 mgl^{-1} to 1.69 mgl^{-1}. The minimum content was noted at station- II and maximum at station- V. The average value was observed as 0.75 mgl^{-1}.

3.1.7. Phosphate

Maximum phosphate content (0.16 mgl^{-1}) in Hooghly estuary was found in station- II station while lower content (0.09 mgl^{-1}) was

recorded at station- III. The average value was marked as 0.13 mgI-[1].
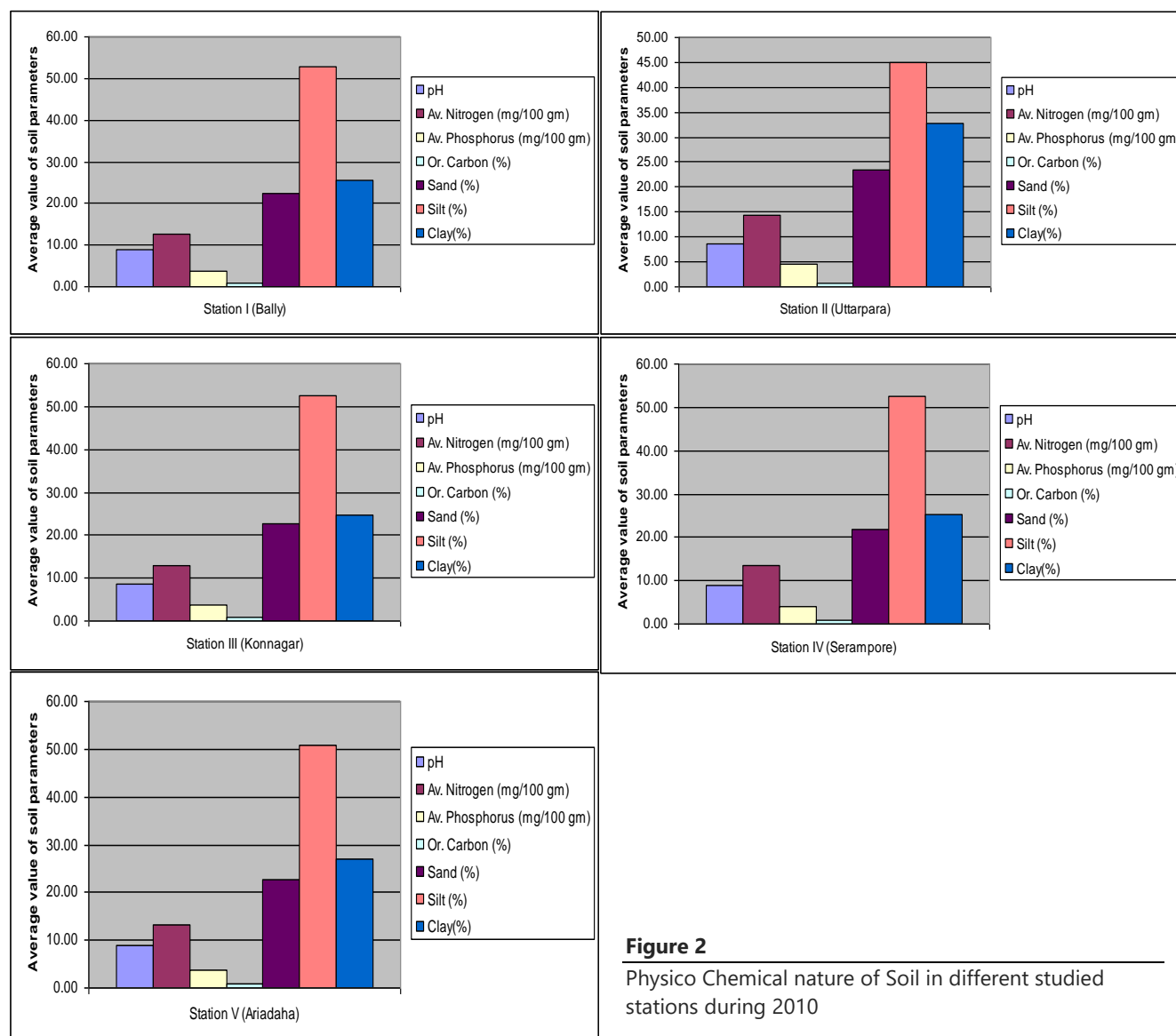
Figure 2

Physico Chemical nature of Soil in different studied stations during 2010

3.2. Physico-Chemical Characteristics of Soil

In Hooghly estuary and its different centers the soil is alluvial and mostly silty-clay load in texture. The soil characteristics in the observed station are depicted in Table 2 & 4 and in Figure 2. Hooghly estuary receives nutrient loaded sediment the Ganga reverine system. The fertile soil continues to be distributed over all the distributaries during high tide. The bottom sediments subjected to the possess of high tide bas well as during low tide, are well marked up continually to release nutrients into the water phase imparting productivity.

3.2.1. Soil pH

The soil pH ranged from 8.70-8.82 in different studied stations. The soil reaction of Hooghly estuary and its observed stations were slightly alkaline (pH ranged 8.1 to 9.1) which was conducive for aquatic productivity.

3.2.2. Available Nitrogen

Maximum available nitrogen (14.41 mg/100g) was noted at station-II followed by station-IV, station-V and station-III. The lower content was (12.79 mg/100g) found at station-II. Considering all stations the average available nitrogen was observed as 13.28 mg/100g.

3.2.3. Available Phosphorus

Maximum available phosphorus (4.60 mg/100g) was observed at station-II followed by station-IV (3.92 mg/100g); station-V (3.86 mg/100g) and station-III (3.63 mg/100g) while the lowest content was seen at station-I (3.61 mg/100g). The average phosphors content in respect to all stations appeared as 3.92 mg/100g.

Table 7

Number and Amount (Kg.) of landed Hilsha fishes per boat during 2010, Station – I (Bally)

Amount (Kg.) of landed Hilsha fishes [Amount in Parenthesis]						
Time in Month	Av Wt: 1.1 Kg (Range 1000-1200 gm)	Av Wt: 0.95 Kg (Range 900 - 1000 gr)	Av Wt: 0.75 Kg (Range 700 - 800 gr)	Av Wt: .55 Kg (Range 500 - 600 gr)	Av Wt .35 Kg (Range 300- 400 gr.)	Total Weight (Kg)
January				4.0 (2.20)	6.5 (2.28)	**4.48**
February				3.0 (1.65)	6.4 (2.24)	**3.89**
March					10.5 (3.68)	**3.68**
April					7 (2.45)	**2.45**
May						
June						
July			3.8 (2.85)	9.7 (5.34)		**8.19**
August	1.1 (1.21)	3.8 (3.61)	9 (6.75)	5.5 (3.03)		**14.60**
September			12 (9.0)	11 (6.05)		**15.05**
October						
November						
December						
Total :	**1.10 (1.21)**	**3.80 (3.61)**	**24.80 (18.60)**	**33.20 (18.27)**	**30.40 (10.65)**	**52.34**

Table 7

Number and Amount (Kg.) of landed Hilsha fishes per boat during 2010, Station – II (Uttarpara)

Amount (Kg.) of landed Hilsha fishes [Amount in Parenthesis]						
Time in Month	Av Wt: 1.1 Kg (Range 1000-1200 gm)	Av Wt: .95 Kg (Range 900 - 1000 gr)	Av Wt: .75 Kg (Range 700 - 800 gr)	Av Wt: .55 Kg (Range 500 - 600 gr)	Av Wt .35 Kg (Range 300- 400 gr.)	Total Weight (Kg)
January				3.50 (1.93)	5.60 (1.96)	**3.89**
February				2.8 (1.54)	5.5 (1.93)	**3.47**
March					7.00 (2.45)	**2.45**
April					12.25 (4.29)	**4.29**
May						
June						
July			7.5 (5.63)	6.5 (3.58)		**9.21**
August		1.8 (1.71)	12 (9.00)	5.3 (2.92)		**13.63**
September	2.2 (2.42)	2.7 (2.97)	7.5 (5.78)	3.3 (1.82)		**12.99**
November						
December						
Total :	**2.20 (2.42)**	**4.50 (4.68)**	**27.00 (20.41)**	**21.40 (11.79)**	**30.35 (10.63)**	**49.93**

Table 7

Number and Amount (Kg.) of landed Hilsha fishes per boat during 2010, Station – III (Konnagar)

Amount (Kg.) of landed Hilsha fishes [Amount in Parenthesis]						
Time in Month	Av Wt: 1.1 Kg (Range 1000-1200 gm)	Av Wt: .95 Kg (Range 900 - 1000 gr)	Av Wt: .75 Kg (Range 700 - 800 gr)	Av Wt: .55 Kg (Range 500 - 600 gr)	Av Wt .35 Kg (Range 300-400 gr.)	Total Weight (Kg)
January			3.50 (2.63)	6.40 (3.52)		6.15
February			3.20 (2.40)	6.50 (3.58)		5.98
March					10.00 (3.50)	3.50
April					8.75 (3.06)	3.06
May						
June						
July			11.50 (8.63)	7.30 (4.01)		12.64
August		5.70 (5.42)	11.25 (8.44)	6.60 (3.63)		17.49
September		3.80 (3.61)	9.00 (6.75)	5.50 (3.03)		13.39
November						
December						
Total :		9.50 (9.03)	38.45 (28.85)	32.30 (17.77)	18.75 (6.56)	62.21

3.2.4. Organic Carbon

The organic carbon content ranged from 0.79% to 0.85% in different studied stations. Maximum organic carbon (0.85%) was recorded at station-I and the minimum was seen at station-IV. In totality the average organic carbon content appeared as 0.81%.

3.2.5. Soil Texture

Sand, silt and clay contents were observed in the soil of the studied stations. Among these elements silt appeared in greater amount (50.69%) followed by clay (27.03%) and sand (22.57%) contents. In these stations silt content ranged 44.92% to 52.75% and maximum percentage of silt was seen at station-I and minimum was recorded at station-II. Sand content ranged 21.92 to 23.33% and the average percentage of sand content was seen as 22.57%. Clay content ranged from 24.65% to 32.67% and the average value was 27.03%.

Table 7 Number and Amount (Kg.) of landed Hilsha fishes per boat during 2010, Station – IV (Serampore)

Amount (Kg.) of landed Hilsha fishes [Amount in Parenthesis]						
Time in Month	Av Wt: 1.1 Kg (Range 1000-1200 gm)	Av Wt: .95 Kg (Range 900 - 1000 gr)	Av Wt: .75 Kg (Range 700 - 800 gr)	Av Wt: .55 Kg (Range 500 - 600 gr)	Av Wt .35 Kg (Range 300-400 gr.)	Total Weight (Kg)
January			4.50 (3.38)	6.10 (3.36)		6.74
February			4.00 (3.00)	4.80 (2.64)		5.64
March					9.5 (3.33)	3.33
April					12.25 (4.29)	4.29
May						
June						
July			4.50 (3.38)	10.15 (5.58)		8.96
August	1.10 (1.21)	2.85 (2.71)	9.00 (6.75)	9.15 (5.03)		15.70
September	1.10 (1.21)	5.70 (5.42)	9.00 (6.75)	4.95 (2.72)		16.10
November						
December						
Total :	2.20 (2.42)	8.55 (8.13)	31.00 (23.26)	35.15 (19.33)	21.75 (7.62)	60.76

Table 7

Number and Amount (Kg.) of landed Hilsha fishes per boat during 2010, Station – V (Ariadaha)

Amount (Kg.) of landed Hilsha fishes [Amount in Parenthesis]						
Time in Month	Av Wt: 1.1 Kg (Range 1000-1200 gm)	Av Wt: .95 Kg (Range 900 - 1000 gr)	Av Wt: .75 Kg (Range 700 - 800 gr)	Av Wt: .55 Kg (Range 500 - 600 gr)	Av Wt .35 Kg (Range 300- 400 gr.)	Total Weight (Kg)
January			5.80 (4.35)	6.80 (3.74)		**8.09**
February			4.60 (3.45)	5.50 (3.03)		**6.48**
March					9.20 (3.22)	**3.22**
April					9.80 (3.43)	**3.43**
May						
June						
July			9.75 (7.31)	7.50 (4.13)		**11.44**
August	2.20 (2.42)	2.85 (2.71)	12.00 (9.00)	8.50 (4.68)		**18.81**
September	1.10 (1.21)	3.80 (3.61)	11.25 (8.44)	3.30 (1.82)		**15.08**
November						
December						
Total :	**3.30** (3.63)	**6.65 (6.32)**	**43.40 (32.55)**	**31.60 (17.40)**	**19.00 (6.65)**	**66.55**

Table 8

Amount of landed Hilsha fishes per boat per station during 2010

Amount (Kg.) of landed Hilsha fishes							
Time in Month	Station I	Station II	Station III	Station IV	Station V	Sum	Percentage
January	4.48	3.89	6.15	6.74	8.09	**29.35**	**10.05**
February	3.89	3.47	5.98	5.64	6.48	**25.46**	**8.73**
March	3.68	2.45	3.50	3.33	3.22	**16.18**	**5.54**
April	2.45	4.29	3.06	4.29	3.43	**17.52**	**6.00**
May							**0**
June							**0**
July	8.19	9.21	12.64	8.96	11.44	**50.44**	**17.28**
August	14.68	13.63	17.49	15.70	18.81	**80.31**	**27.52**
September	15.05	12.99	13.39	16.10	15.08	**72.61**	**24.88**
October						**0**	**0**
November						**0**	**0**
December						**0**	**0**
TOTAL	**52.34**	**49.93**	**62.21**	**60.76**	**66.55**	**291.87**	**100.00**

3.3. Heavy Metals contents in Water

The heavy metal contents of water in the studied stations have been presented in Table 5 & in Figure 3A.

The zinc content in water ranged 0.01 to 0.08 mgl[-1]. The minimum concentration was seen at station-I and maximum concentration was observed at station-V. However zinc concentration appeared with same value in stations II, III, IV. In general, Zn content in water was low and within permissible range for aquatic environment.

Lead content varied from 0.15 to 0.62 mgl[-1]. The minimum average value (0.30 mgl[-1]) of the metal was seen at station-V while maximum average value (0.50 mgl[-1]) at station-I. The data indicated that in all stations of Hooghly estuary lead content was above the permissible range.

Cadmium content in water ranged 0.03 to 0.50 mgl[-1]. The minimum average (0.05 mgl[-1]) value of the metal was seen in station-I and maximum average value' (0.43 mgl[-1]) was at station-II. Cadmium concentration remained above the safe limit in all station except station-I.

The copper content in waters apparently did not exceed safe limits. The concentration of copper showed lower value (0.04 mgl[-1]) at station-I and maximum value at station-V (0.05 mgl[-1]).

Chromium content in the estuarine water ranged from 0.01 to 0.09 mgl[-1] and its mean value appeared as 0.04 mg/l. The data indicated that the average chromium content in station-I and station-V was below the permissible range while at stations II, III and IV, the values were slightly above.

Zinc content in soil varied from 28.48 to 86.90 mgl[-1] with minimum (51.02 mgkg[-1]) beings recorded at Sally station and maximum (58.20 mgkg[-1]) at Ariadaha station. The average value was marked as 58.20 mgkg[-1].
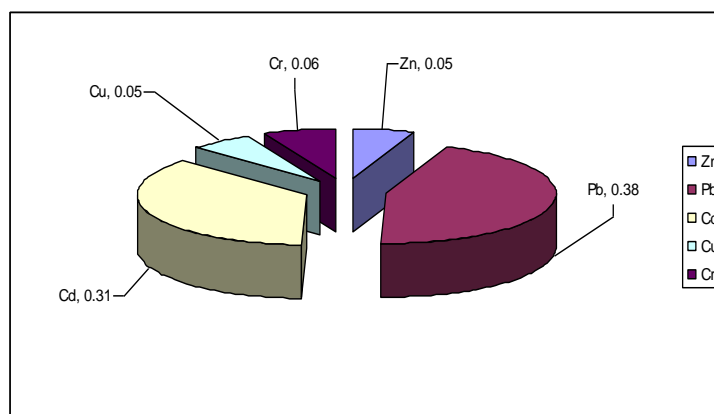
Figure 3A

Relative distribution of heavy metals in water in different
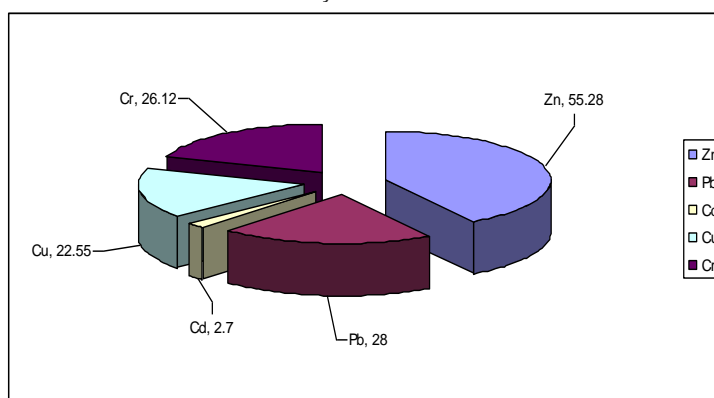
Figure 3B

Relative distribution of heavy metals in Soil in different studied stations during 2010

Group	Weight in gm.	Length in cm. (Average)	Breadth in cm. (Average)
I	1000-1200	33.24	10.81
II	900-1000	31.67	9.87
III	700-800	27.36	9.06
IV	500-600	24.62	7.16
V	300-400	22.65	6.20

3.4. Heavy Metals Content in Soil

The heavy metal contents of soil in the studied station have been presented in Table 6 & in Figure 4.

The zinc content in soil ranged 28.48 to 86.90 mgkg-^{1} in respect to all studied stations. The minimum concentration was seen at station-I and maximum concentration was observed at station-V. The average value of Zn content in soil was marked as 55.28 mgkg-^{1}.

Lead content showed increasing trend and it ranged from 11.00 to 42.60 mgkg-^{1}. The minimum amount (13.90 mgkg-^{1}) was seen at station-I and maximum amount (37.80 mgkg-^{1}) was seen at station-II. In respect to all stations the average value of lead appeared as 28.00 mgl-^{1} .

Cadmium content ranged 1.62 to 5.22 mgkg-^{1}. From average data the minimum value (2.01 mgkg-^{1}) of cadmium was seen at station-IV and maximum value (4.66 mgkg-^{1}) at station-III. Considering all stations the average value of all stations appeared as 2.70 mgkg-^{1}.

Copper content also ranged 12.00 to 34.43 mgkg-^{1}. The average minimum value (14.11 mgkg-^{1}) was marked at station-I while maximum value (33.61 mgkg-^{1}) was noticed at station-III. On behalf of all stations the average value was observed as 22.55 mgkg-^{1}.

Chromium content prevailed in the studied station with the range of 15.32 to 36.06 mgkg-^{1}. From average value minimum (19.74 mgkg-^{1}) and maximum (28.34 mgkg-^{1}) were noticed at station-IV and station-II respectively. In respect to all studied stations the average value appeared as 26.12 mgkg-^{1}.

3.5. Hilsa Fish Incidence

The incidence of hilsa fishes has been depicted in the Tables 7, 8, 9 and Figure 5. These said tables reveal that the hilsa fishes appeared twice in a year. The first incidence was marked during January to April and the second incidence during July to September (Vide Table 7 & 8). The former incidence (Post-monsoon) ranged 9.62% to 10.92% while the latter (Monsoon incidence) ranged 16.28% to 22.83%.

During the study period (January to December, 2010) the landed hilsa fishes were seen in five categories considering their weight length and breadth. There are description is mentioned below. From Table 7 it appears that the monsoon peak was constructed by the third and fourth groups of hilsa fishes and the post monsoon peak by both adults and juveniles.

Round the year total amount of landed fishes per boat per station has been depicted in the Table 8. It reveals that the total annual catch per boat per station ranged from 85.45 Kg. to 103.95 Kg. The minimum amount of annual catch was marked in Station II and the maximum was observed in Station V. Regarding annual catch maximum amount (22.83%) of landed fishes was observed during August.

The variation in weight and length has been presented in Table 9. The said table reveals that among the landed fishes the greater amount of catch (42.38%) was observed in favor of fishes bearing average weight of 750 gm with length 27.36 cm. and breadth 9.06 cm. Lesser amount of annual catch was seen in favor of fishes bearing average weight as 1100 g with length and breadth as 33.25 cm. and 10.81 cm. respectively.

The morphometric analyses of the observed fishes were made with the correlation between weight versus length and weight versus breadth. The said analyses had been done with the concerned fishes of all the studied stations. The regression lines obtained from the analyses showed negative correlation between weight versus length and weight versus breadth. The situation was true for all the studied station (Vide Figure 6).

3.6. Hilsa Catch Drive & Fishermen's Features

Table 10 depicts the hilsa fishing performance of the fishermen associated with studied stations. The said table reveals that during hilsa season (average 6 months in the year including post-monsoon and monsoon seasons) fishermen could perform fishing drives 46.54% to 58.58% days and average value appeared as 52.58% days. Among the fishing drive period they could receive effective fish catches only 50 to 64.54% days (average 59.08% days). The effective fishing drives with annual yield amount per boat per station ranged from 49.90 Kg. to 60.38 Kg. and average as 54.20 Kg during 2010 where as during 2005 the annual yield per boat per station ranged from 82.15 Kg. to 103.56 Kg. and average as 90.25 Kg. in the said studied stations. Again, the reduction of yield amount during 2010 ranged from 32.25 Kg. to 43.18 Kg and average as 37.87 Kg. per boat per station. This also depicted the reduction percentage ranged from 39.25% to 43.35% and an average as 41.50%. Again, the said table reveals that only very limited persons (18.16% to 22.31%, average as 20.21%) in the concerned fishermen community (studied stations linked fishermen) were involved in hilsa catch performance during 2010 where as the said involvement was seen to be participated by greater amount of persons (35.16% to 45.28%, average as 39.88%) during 2005. Regarding the low yield of hilsa fishes in the estuary, most of the fishermen referred various factors including pollution of water, low salinity, poor entry of adult fishes, juvenile killing and use of mesh nets.

Table 9
Amount of landed Hilsha fishes per boat with weight, length and breadth during 2010

Amount (Kg.) of landed Hilsha fishes						
Studied Station	Av Wt: 1.1 Kg Av L= 33.24 cm. Av B= 10.81 cm.	Av Wt: 0.95 Kg Av L= 31.67 cm. Av B= 9.87 cm.	Av Wt: 0.75 Kg Av L= 27.36 cm. Av B= 9.06 cm.	Av Wt: .55 Kg Av L= 24.62 cm. Av B= 7.16 cm.	Av Wt .35 Kg Av L= 22.65 cm. Av B= 6.20 cm.	Total Weight (Kg)
Station - I (Bally)	1.21	3.61	18.60	18.27	10.65	52.34
Station - II (Uttarpara)	2.42	4.68	20.41	11.79	10.63	49.93
Station - III (Konnagar)	0.0	9.03	28.85	17.77	6.56	62.21
Station - IV (Serampore)	2.42	8.13	23.26	19.33	7.62	60.76
Station - V (Ariadaha)	3.63	6.32	32.55	17.40	6.65	66.55
Total:	9.68	31.77	123.67	84.56	42.11	291.79
Percentage	3.32	10.89	42.38	28.97	14.44	

Table 10
Attributes of Fishermen engaged in catching of Hilsha fishes in the studied stations during 2010

Features of Fishermen	Station I	Station II	Station III	Station IV	Station V	Average
I) Number of persons/ boat engaged in Hilsa catch	3.2	2.8	3.1	2.6	3.5	3.04
II) Number of days involved in Hilsa catching out of 180 days (%)	46.54	50.28	55.35	52.17	58.58	52.58
III) Number of days with successful drives (%)	50.00	62.85	55.55	62.50	64.54	59.08
IV) Total annual yield amount (Kg.) per boat per station during 2005(Data received from concerned fishermen)	90.64	82.15	95.60	103.56	88.32	90.25
V) Total annual yield amount (Kg.) per boat per station during 2010 (vide Table 8)	53.40	49.90	54.25	60.38	53.07	54.20
VI) Reduction of yield amount & % during 2010 in respect to 2005	37.24 (41.08%)	32.25 (39.25%)	41.25 (43.35%)	43.18 (41.65%)	35.25 (42.17)	37.87 (41.50%)
VII) Number of persons engaged in fishing in fishermen community during 2005 (%)	40.42	45.28	38.35	35.16	40.22	39.88
VIII) Number of persons engaged in fishing in fishermen community during 2010 (%)	20.34	22.31	20.18	18.16	20.99	20.21
IX) Remarks of Fishermen regarding poor yield	Polluted water	Low salinity & Pollution	Random catching of juvenile fishes	Poor entry of adult fishes	Polluted water	Polluted water

4. DISCUSSION

4.1. Water Parameters

In present observation, no significant differences in temperature variation in the studied stations are observed. The monthly average temperature of the stations ranged 23.55 - 24.91^{o}c; as the temperature below 30°c is presumed to be very bad for fish growth (Nath and Srivastava, 2001). The dissolved oxygen amount ranged from 3.70 to 6.27 mgl^{-1} and the average amount appears as 5.84 mgl^{-1} which is detrimental to fish health and the water body is referred as polluted (Saha and Mondal, 2003). However, the present findings are well agreement with the observations of Laal et al., (1986); Sinqh et al., (1997); Pathak et al., (2001) and Gurumanyum et al., (2001).

The carbon-di-oxide amount shows variations (4.73 - 5.61 mgl^{-1}) in different stations and the average amount appear as 5.22 mgl^{-1}. Increased free CO_2 amount during post monsoon is perhaps due to increase in decayed organic matters brought by the flood water (Gurumayum et al., 2001).

The total nitrate content of water is relatively low and fluctuates in different seasons and in different stations but the range is relatively high when salinity in low. The phosphate content is seen to be relatively high when salinity is low and as the salinity increases phosphate content declines. High phosphate content in estuarine water indicates that the estuary receives nutrient from its feudal catchment areas. These findings are well accord with the observations of Nath and Srivastava, (2001) and Bhaumik, (2003). Salinity in the estuary is marked relatively moderate. In previous observation in the upper stretch of Hooghly estuary, the salinity was recorded as 0.05 mgl^{-1} but present observation does not compromise with it. Water of the estuary shows moderate salinity (Nath et al., 2004).

4.2. Soil Parameters

The soil pH is seen to prevail within the range, of 8.70 to 8.82. It is somewhat more. From earlier record the soil pH of the estuary was at the range of 6.5 to 7.5 and was considered ideal and favorable for fish growth (Saha, 2003). The present observation does not compromise with the earlier observation and the present study denotes the adverse situation for fish growth. Organic carbon content is seen in higher amount in all the observed stations. Soil having less than 0.5% organic carbon is considered low productive while the range of above 0.5% to 0.7% are considered as medium productive (Saha, 2003). In present observation, organic carbon content is seen to be relatively high amount. The soil reaction is slightly alkaline which is by and large conducive for aquatic life. The moderate amounts of available nitrogen and available phosphorus indicate that the nutrient release is very facile in this system under the supportive and favorable condition.

4.3. Heavy Metals

Heavy metals are the normal constituents in the marine and estuarine environment. Pollution of Hooghly estuary with heavy metals has been in the rising trend (Mitra et al., 1994). In Hooghly estuary heavy metals like zinc, lead, cadmium, copper and chromium are located both in water and soil in permissible limit but the high amount of lead is observed and this indicates the pollution state of the estuary. Metal pollution has been documented from the upper and middle stretch in Hooghly estuary (Singh et al., 1993; Verma 1995 and Munshi et al., 2000) and also observed that many species had vanished from Subarnarekha river due to heavy metal pollutions, From above observation, it is apparent that the total catch of landed hilsa fish has been lowered extremely. In winter period the juvenile catch has also been reduced and that indicates that proper breeding of the fish is being hampered. Highest amount of catch was seen during August. In water, among the heavy metals lead and chromium are marked above the permissible limit. In soil zinc and lead are seen above the permissible limit. In totality, the heavy metal contents in all studied stations are marked with high amount indicating the pollution state of the estuary. Such findings corroborate well with the observations of Singh et al., (1993), Mitra et al., (1994); Verma, (1995); Munshi et al., (2000).

4.4. Incidence of Hilsa Fishes

From the data depicted the incidence of hilsa fish (vide Tables 7, 8 and 9) in different studied stations, it appears that the upward migration of hilsa fish is made by full grown forms during monsoon and during winter the downward migration is made by both adult and juveniles. In upward migration fishes bearing weight more than one kg were very minimum and in downward migration the incidence of juvenile forms was also low that is quite unnatural to hilsa fishes at least in Hooghly estuary. During 2006 - 2007 reduction of migration of hilsa fishes in the estuary had been observed (Banerjee et al., 2010). Annual hilsa catch is seen to be reduced as about of 1/3 of the amount of landed fishes of 5 years back. This denotes that hilsa migration in the estuary has drastically declined. From morphmetric analysis, it has also been seen that length and breadth of the fishes of the standard hilsa fishes (average weight 1.1 Kg.) have been reduced. Usually the full grown hilsa fish (average weight 1.1 Kg.) shows length and

breadth as 35.65 cm. and 14.25 cm respectively (Nath et al., 2004) where as in present observation the fishes having same weight show length and breadth as 33.24 cm and 10.81 cm respectively. Again, the negative correlation in the regression lines (vide Figure 6) denotes inconvenience in the growth of the hilsa fishes in the estuary. In totality, the less arrival, low growth and poor breeding of the hilsa fishes in the estuary have been documented. The present observation is well accord with the findings of Dey and Dutta (1990); Rahman, (2000) and Halder et al., (2005).
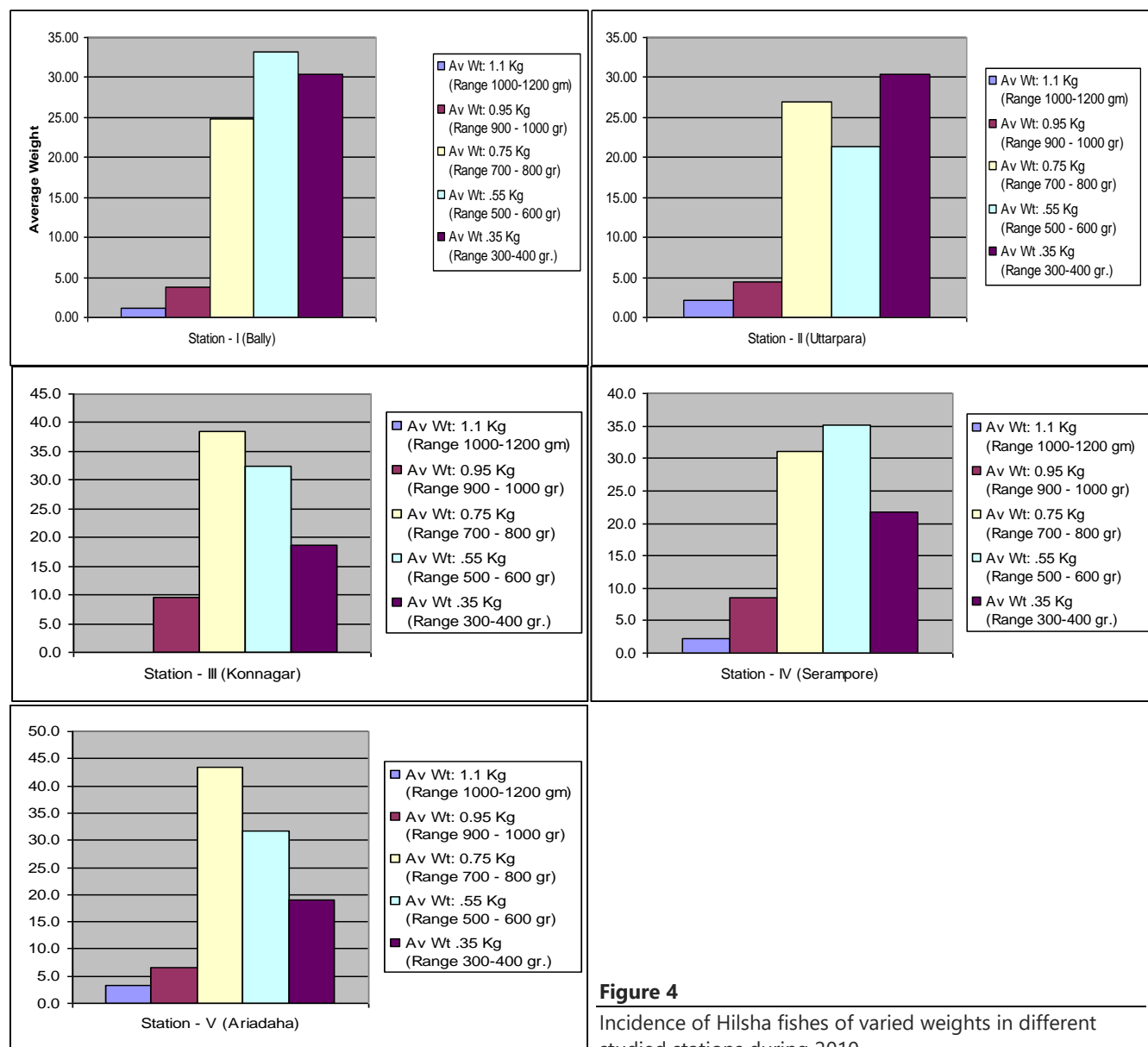
Figure 4

Incidence of Hilsha fishes of varied weights in different studied stations during 2010
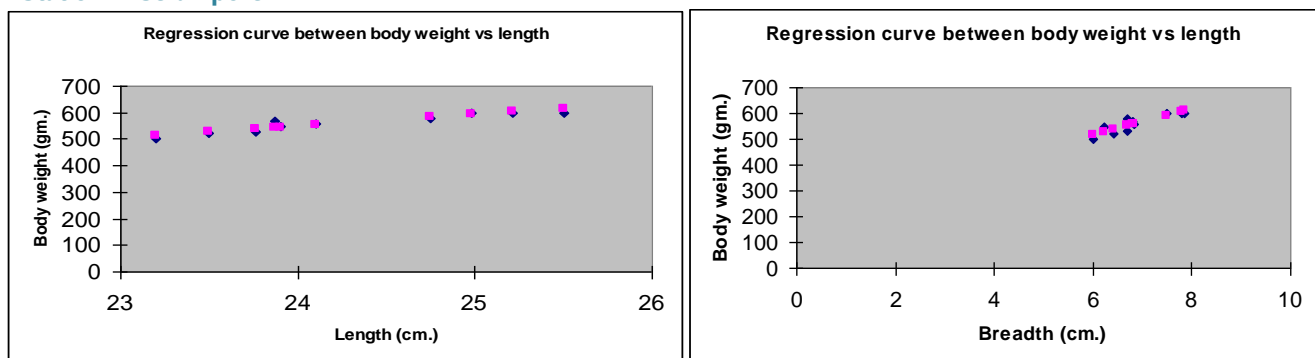
4.5. Fishing Drive and Hilsa catches

Another scenario is presented in Table 10 which reveals the fishermen's conditions in connection with the hilsa migration in the estuary. Hilsa fishing is quite unnatural to other fishing types. It is a time consuming drive and requires minimum three persons per boat. Hilsa fishing cannot be done regularly rather it is launched periodically. At present situation fishermen are not properly awarded with fishes in all the drives. In many more times they may have minimum amount of fishes or not at all in spite of releasing fund, energy and time. Besides these, the annual catch is also seen to be reduced day by day. In these situation fishermen of the station allied sites have given up fishing profession and have been engaged themselves in other occupation besides fishing. This scenario denotes the deviation of performance from skilled occupation. Whenever the said fishermen are asked to comment something from their previous experience regarding the situation most of them replied that the quality of water of the estuary has

been changed and not favorable for the breeding of hilsa fishes. Considering all these it is evident that pollution state of the estuary appears as a major hindrance for the migration of hilsa fishes and that demands immediate monitoring of control measures to save the water body and the fascinating fish species (*Tenualosa ilisha*) of the estuary.
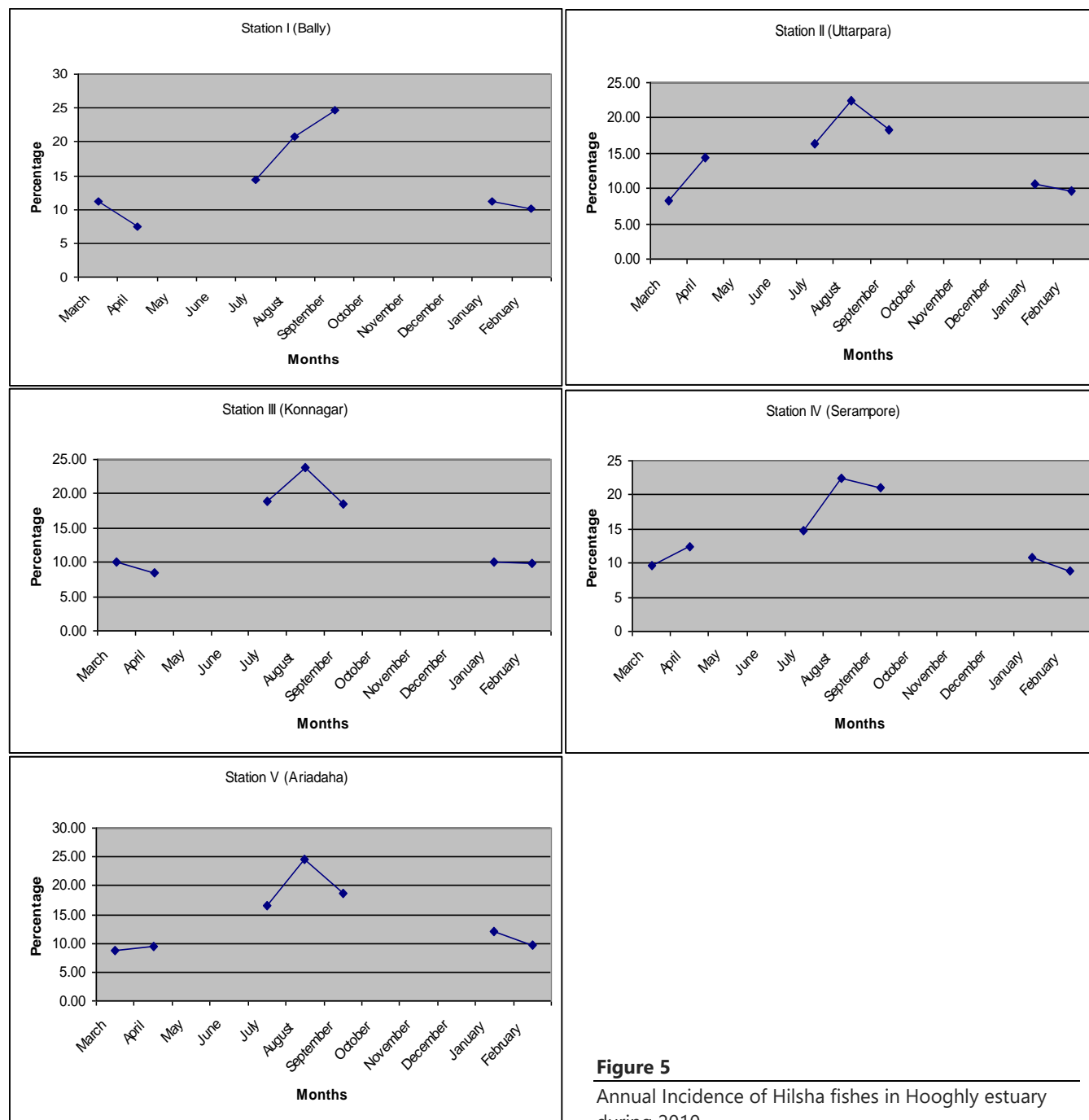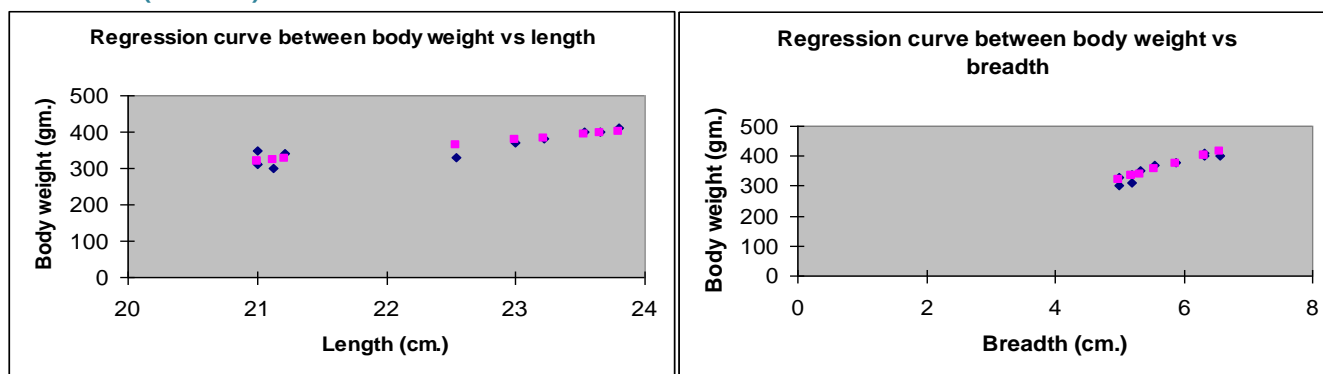

Figure 5

Annual Incidence of Hilsha fishes in Hooghly estuary during 2010

Station I (Ballv)

Regression curve between body weight vs length

Regression curve between body weight vs breadth

Station II (Uttarpara)

Regression curve between body weight vs length

Regression curve between body weight vs breadth

Station III (Konnagar)

Regression curve between body weight vs length

Regression curve between body weight vs breadth

Station IV Serampore

Regression curve between body weight vs length

Regression curve between body weight vs length
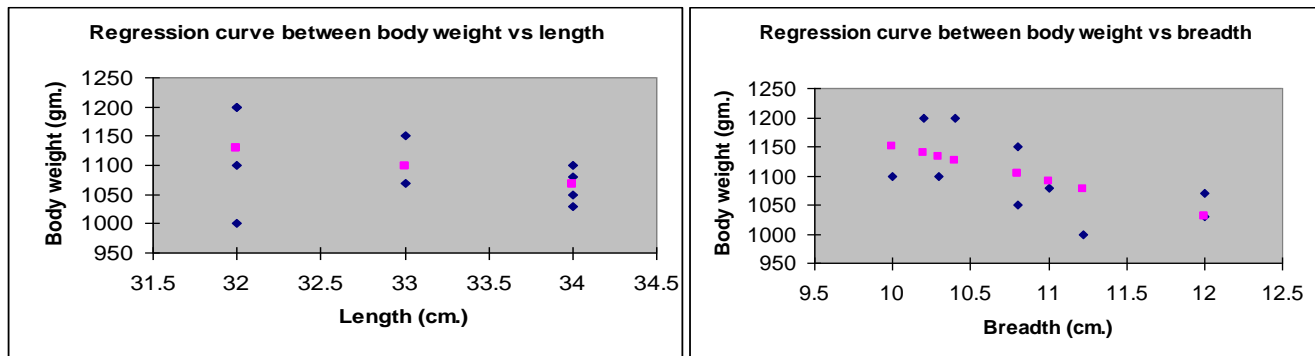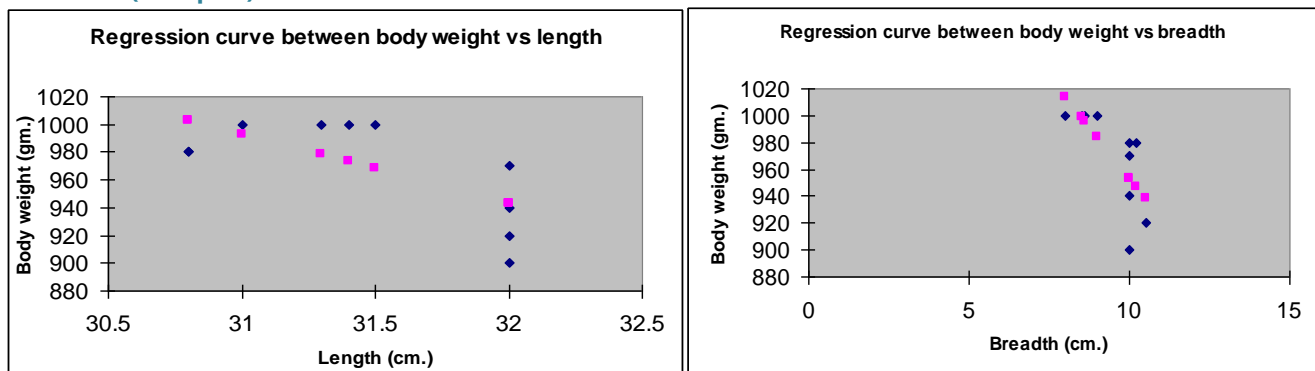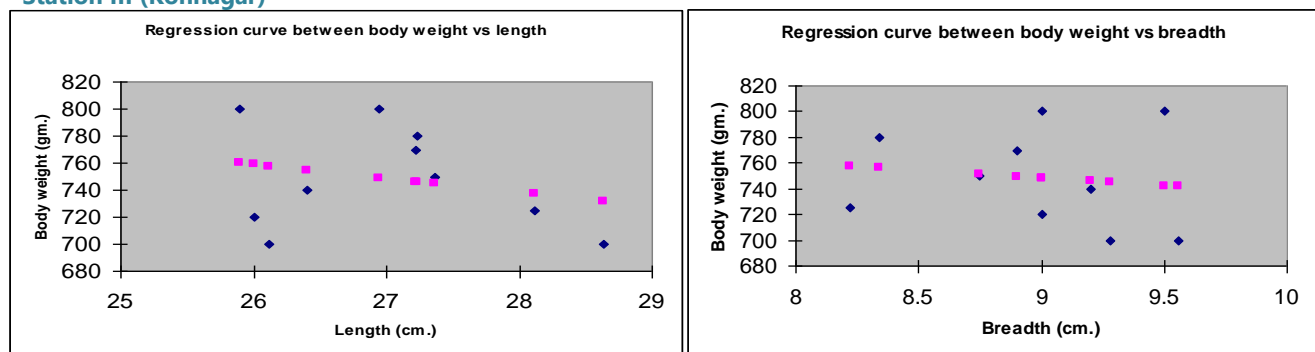
Figure 6

Morphometric analysis (Correlation between body weight Vs. length & breadth) of Hilsha fishes in Hooghly estuary during 2010

Station V (Ariadaha)

Figure 6 (Continues)

Morphometric analysis (Correlation between body weight Vs. length & breadth) of Hilsha fishes in Hooghly estuary during 2010

Figure 6 b
Studied Stations

Figure 6 c
Hilsha fishes from different studied stations

5. CONCLUSION

The study enables us to draw the following conclusions.

a) Water body of Hooghly estuary is running with less dissolved oxygen and more phosphorus content which indicates a pollution state of the estuary and adverse environmental condition for the growth of fishes.

b) The soil contents of the estuary represents more pH (alkaline nature), more organic carbon content and more lead content (heavy metal) which indicates an ecological degradation leading to the stress situation for the fishes specially in respect to their growth and reproduction.

c) The morphmetric observation shows the reduction sizes (both length and breadth) of hilsa fishes along with their low weight which infers unsuitability of habitat nature for the concerned fishes.

d) Very low amount of landed fishes, unavailability of full grown fishes (1 to 1.5 kg in weight) and fewer amounts juvenile fishes (300 - 400 gm in weight) denote. unfavorable environmental nature for growth and reproduction of the concerned fishes.

e) The extreme reduction of yield of hilsa catch in Hooghly estuary creates social problems in fishermen society and they give up skilled occupation and have forced to be engaged in new jobs to maintain livelihood.

f) Catching of juveniles should be prohibited.

g) The study states that all round effort should be paid to check environment pollution of the estuary, and to save the aquatic animals there in.

Use of small meshed nets should be banned immediately.

Conflict of Interest

The authors declare no conflicts of interests any matter related to this paper.

Data and materials availability

All related data have been presented in this paper.

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